A Giant Step in Jetliner Propulsion

A cleaner, quieter, more economical aircraft engine heads technology transfers in the field of transportation

In November 1995, the General Electric GE90 turbofan engine made its flight debut aboard a Boeing 777 jetliner operated by British Airways. Developed and manufactured by GE Aircraft Engines (GEAE), Cincinnati, Ohio, in concert with program participants in France, Italy and Japan, the GE90 is one of the most powerful air breathing engines ever flown. It is also one of the most efficient, one of a trio of advanced technology, very high thrust jetliner engines that offer new levels of operating economy and environmental acceptability.

The GE90's history underlines the lengthy time and large investment—$1.5 billion in this instance—required to bring a major aerospace system from concept to service entry. By the time it was certified in 1995, the engine had been several years in development. Actually, though, some of the key technologies incorporated in the GE90 trace their roots to joint GE/NASA research in the 1970s.

The GE90 was initially certified at 84,700 pounds thrust, but it is capable of thrust levels well beyond that. Only two engines are required to power the big widebody 777, which approaches in size the four-engine Boeing 747 jumbo jet.

It is a type of engine known as a high bypass turbofan. Used in most modern airliners, the turbofan is a propulsion system in which some of the air taken in is compressed, burned in a combustor and expelled to generate power for driving the fan and compressor. A greater amount of the air bypasses the combustion process. In the GE90, the relatively cool bypass air is pushed rearward by a huge (123-inch-diameter) multibladed fan to mix with the hot exhaust gas; the result is a very large gain in overall thrust with minimal fuel expenditure.

A GE Aircraft Engines technician is dwarfed by the mammoth GE90 jetliner engine, which incorporates multiple technologies developed in joint GE/NASA research programs. The large sphere is a test structure.

Propulsion engineers use the term "bypass ratio" to indicate how much of the ingested air bypasses the combustion chamber; generally speaking, the higher the ratio, the more efficient the engine. The GE90's very high 9:1 ratio makes a big contribution to noise and fuel burn reductions. Specifically, the GE90 features a fuel consumption rate 10 percent better than the large commercial turbofans of the pre-1995 generation; a noise level two decibels lower; and emission reductions of oxides of nitrogen (35 percent), carbon monoxide (25 percent) and unburned hydrocarbons (60 percent).

These features have great attraction for airline operators. Fuel is one of the major elements of total operating costs, and fuel efficiency of the order the GE90 offers is vitally important to the world's airlines, who are just beginning to recover financial equilibrium after years of heavy losses. The engine's environmental characteristics provide a valuable bonus, not only in community good will but in a further contribution to improved airline earnings through avoidance of noise and emissions taxes now being levied by foreign nations.

Although GEAE spent years refining them, the basic fuel consumption and environmental improvement technologies that provided the springboard for what eventually became the GE90 stemmed from the company's participation in two NASA research programs.

The first, initiated in 1969 and continuing through the 1970s, was the Quiet Clean Short-haul Experimental Engine (QCSEE) program conducted by Lewis Research Center. QCSEE focused on then-advanced technologies to lower engine noise and address the most troublesome aircraft-emitted contaminants. The program was eminently successful; ground tests of research engines in the 40,000-pound-thrust class demonstrated noise reductions 8-12 decibels (60-75 percent) below the quietest engines in civil transport service. They also demonstrated new technologies to effect sharp reductions in emissions of carbon monoxide and unburned hydrocarbons.

Also in the 1970s, GEAE joined with NASA in a joint Energy Efficient Engine (E^3) program managed by Lewis Research Center. Like QCSEE, E^3 targeted emission reductions, but emphasized new design techniques for minimizing fuel burn. Highlighting that program was development of a new type of compressor core and an advanced combustor. The GE90's compressor and dual-dome combustor are direct descendants of technology developed in the E^3 program and thoroughly proven in extensive ground tests; they are the principal factors in the engine's economical fuel burn, reduced emissions and low maintenance cost features.

In developing the GE90, the company drew upon technology gained from multiple sources, including the NASA experience; expertise acquired in building high thrust systems for military aircraft; and GEAE's development and manufacture—in cooperation with SNECMA of France—of the CF6 and CFM56 families of engines, which have years of service with many of the world's airlines.

The development effort began in the late 1980s and progressed to hardware test in 1992. The ground and flight test program was the most exhaustive ever undertaken by the company, involving some 7,600 hours and 19,000 cycles of endurance testing to simulate more than two years of actual airline experience and maintenance.

Thrust levels of the GE90 series continue to increase. The first growth model—the GE90-92B—achieved its rated thrust of 92,000 pounds in the spring of 1996. Research engines have topped that; the GE90 has operated for more than 150 hours at thrust levels above 100,000 pounds, and has demonstrated a thrust capability of 110,000 pounds. The engine is designed to power all models of the 777 in development or planned, plus other subsonic commercial widebodies contemplated for introduction over the next 20 years.